Wildl. Soc. Bull. 17:41–45, 1989

RELATIONSHIP OF ROOF RAT POPULATION INDICES WITH DAMAGE TO SUGARCANE

LYNN W. LEFEBVRE, *U.S. Fish and Wildlife Service, 412 N.E. 16th Avenue, Gainesville, FL 32609*

RICHARD M. ENGEMAN, *U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control, Denver Wildlife Research Center, Denver Federal Center, Denver, CO 80225-0266*

DAVID G. DECKER, *U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control, Denver Wildlife Research Center, 2820 East University Avenue, Gainesville, FL 32601*

NICHOLAS R. HOLLER, *U.S. Fish and Wildlife Service, Alabama Cooperative Fish and Wildlife Research Unit, 331 Funchess Hall, Auburn University, AL 36849*

Roof rats (*Rattus rattus*) cause substantial damage to sugarcane in South Florida (Samol 1972; Lefebvre et al. 1978, 1985). Accurate estimates of roof rat populations in sugarcane fields would be useful for determining when to treat a field to control roof rats and for assessing the efficacy of control. However, previous studies have indicated that roof rats exhibit trap shyness, which makes capture-recapture population estimates difficult (Lefebvre et al. 1978, 1985; Holler et al. 1981). Until trapping methods are sufficiently improved to allow accurate population estimates, indices of population size that relate to damage need to be developed. The objectives of our study were to examine the relationship of several indices of roof rat populations to the percentage of sugarcane stalks damaged at harvest; to determine which population index would be most useful for sugarcane growers; and to report on a test of several types of live traps for roof rats.

METHODS

Study Design

We selected 12 7.3-ha sugarcane half-fields (366 × 183 m) in the Western Division of the U.S. Sugar Corporation, Palm Beach County, Florida, in September 1983 (see Lefebvre et al. [1982] for complete description of study area and fields). Selection was made after trapping at least 2 roof rats near edges of fields by using 24 Haguruma® wire mesh live traps for 1 night (use of registered trade name does not imply endorsement of product). Each selected half-field was separated from the others by at least 1 half-field. The same sugarcane variety, C1.59-1052, grew in all fields.

Surveys for rodent damage were conducted monthly near edges of the 12 fields from September through December 1983. We assumed that all or most damage was done by roof rats because the selected fields had predominantly roof rat populations. We limited surveys to field edges because of the difficulty of penetrating the dense tangle of maturing sugarcane stalks and leaves. Damage was monitored by walking into both ends of each field at 8 starting points located approximately 23 m apart. The damage surveyor walked at a relatively constant rate into a field 6 m from each starting point, turned 90°, and walked 6 m before turning again and returning to the field edge. Thus, 16 18-m, U-shaped transects were surveyed per field. No paths were cut for the transects and the starting points were flagged so they would not be reused. We recorded the number of damaged stalks observed per transect. A damaged stalk had at least 1 internode in which the pulp had been consumed and the rind remained intact on only 1 side (a condition referred to as "boated-out").

Rodent activity was monitored monthly in all fields from October to December using tracking tiles. We coated 15-cm^2 ceramic tiles with a suspension of blue carpenter's chalk in acetone, sprayed onto the tiles using a fine mist sprayer (Kaukeinen 1979). Tiles (24/field per night) were placed every 30 m around the 3 accessible sides of each half-field and collected after 24 hours on 2 consecutive days. We determined the percentage of tiles with rodent tracks after 24 and 48 hours for each field.

Livetrapping was conducted monthly from September to December on 2 consecutive nights in each field. We set 48 Haguruma live traps at 15-m intervals around 3 edges of each field. Livetrapping was conducted either before or after placing tiles so that rats would not be in the traps while tiles were exposed.

The 12 study fields were harvested between 7 January and 15 February 1984. Rodent damage was assessed at harvest using methods described by Lefebvre

Table 1. Number of stalks damaged by roof rats counted during monthly surveys, September–December 1983, and percentage of stalks damaged at harvest, January–February 1984, in 12 South Florida sugarcane fields.

Field	Damaged stalks				% stalks damaged at harvest		
	Sep	Oct	Nov	Dec	Overall[a]	Edge[b]	Center[c]
46-P-28	0	3	4	3	0.8	1.2	0.4
45-A-24	0	6	8	17	1.9	2.5	1.4
45-A-19	0	4	16	41	2.3	2.2	2.4
46-F-22	1	4	0	40	2.4	3.2	1.5
45-C-24	0	4	23	76	3.2	2.0	4.5
46-A-34	0	1	0	0	5.0	4.9	5.0
46-J-34	0	2	18	5	6.0	4.6	7.5
45-B-14	2	62	55	118	7.1	7.2	7.1
46-J-15	1	16	37	224	7.2	8.7	5.6
46-E-34	0	7	12	2	7.8	5.4	10.2
46-I-15	7	17	33	144	11.3	11.3	11.4
46-O-15	16	197	77	180	14.6	11.2	18.7

[a] n = 1,650/field, except fields 46-P-28 and 46-O-15, where n = 1,550.
[b] n = 850/field.
[c] n = 800/field, except fields 46-P-28 and 46-O-15, where n = 700.

et al. (1978), but with twice as many sample points per field. This earlier work indicated that damage distribution was unequal between field centers and edges; therefore, we stratified fields and selected a proportional number of sample points from center (24–32) and edge (34) strata. The edge stratum was 46 m wide, and the center stratum was 92–105 m wide. We randomly selected 2 sample points/pile row of cut sugarcane, then pulled 25 stalks of cane from the pile row at each sample point, while taking care to avoid looking at the stalks. The number of stalks with rat damage was recorded, and the proportion of stalks damaged per sample point was determined. The overall percentage of stalks damaged per field was the mean of the percentages per sample point.

In addition to our 12 study fields, we compared roof rat trap success among 3 types of traps on the edges of 2 additional fields. Haguruma live traps were alternated with Tomahawk® and Havahart® live traps at 15-m intervals for 2 consecutive nights monthly from October to December.

Statistical Analyses

We analyzed number of rats captured and percentage of tiles tracked for differences among months, differences between days within months, and for month-by-day interaction using a 2-way analysis of variance (ANOVA) in a randomized block design with fields as blocks. We used randomized block ANOVA to test for differences among the 4 months for the number of stalks damaged in the monthly damage surveys.

Correlations were estimated among the monthly indices. We used only the first day of trapping each month because ANOVA results indicated that trap avoidance occurred on the second day, which could be a source of bias. For calculations of correlations, we used the average percentage of tiles tracked over 2 days each month, resulting in 1 observation for each variable in each field per month (n = 36).

We also calculated correlations for the overall percentage of stalks damaged at harvest on each of the 12 fields (Table 1) with the 4-month average number of rats captured on the first night in each field, and with the 4-month average number of stalks damaged, determined from the monthly damage surveys.

We compared number of rats captured and number of trap failures (closures without captures) by each trap type using 3-way ANOVA's in a randomized block design. The main effects were trap type, month, and 2 consecutive days of trapping. Only 2 fields were used as blocks; therefore, few degrees of freedom were available for testing main effects and interactions.

RESULTS AND DISCUSSION

Monthly Activity Measurements

The interacation of month and day was nonsignificant for both number of rats captured and percentage of tiles tracked ($P > 0.33$). The effect of month was nonsignificant for rat captures ($F = 1.5$; 3,33 df; $P = 0.234$). The number of rats captured on the first day of trapping ($\bar{x} = 4.0$) was higher ($F = 11.53$; 1,11 df; $P = 0.006$) than on the second day ($\bar{x} = 2.0$). The number of rats captured per day per field ranged from 0 to 15. Month was the only variable that affected the percentage of tiles tracked ($F = 12.49$; 2,22 df; $P = 0.002$). Differences existed among each of the 3 months in which tracking tiles were used (Duncan's multiple range test, $\alpha = 0.05$) (Table 2).

We believe that 1 reason these monthly differences were detected is because of low variability in these data (CV range = 5.6–12.2%). Rats tracked most of the tiles in all fields, and on several occasions all tiles in a field were tracked. More tiles per field would be needed to detect variability in rat activity among fields. Use of tracking tiles may only be practical to growers as a means to detect rodent presence, not relative abundance.

The number of stalks damaged differed among months ($F = 7.06$; 3,33 df; $P = 0.001$).

Table 2. Capture of roof rats, percentage of tracking tiles with tracks, and observed numbers of rat-damaged stalks (n = 12 for each mean) in South Florida sugarcane fields, 1983–1984.

	No. captures				% tiles tracked				No. damaged stalks	
	Day 1		Day 2		Day 1		Day 2			
Month	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Sep	3.8	1.18	1.9	0.60					2.3	1.38
Oct	3.7	0.49	0.8	0.27	72.8	6.18	71.8	6.88	26.9	16.20
Nov	4.3	1.22	3.3	0.99	66.9	7.65	60.4	7.38	23.6	6.78
Dec	4.3	0.84	1.8	0.61	79.4	4.48	81.9	8.20	70.8	22.43

There were no differences among the first 3 months; however, December differed significantly from the first 3 (Duncan's multiple range test, $\alpha = 0.05$) (Table 2). Although this increase might enable damage detection in December with less effort, earlier detection in rodent populations might be necessary to protect the crop effectively and safely (fields are harvested between November and March).

The number of roof rats captured on the first night of trapping per field-month had weak correlations with the stalk damage survey (r = 0.28, 47 df, P = 0.01) and the average percentage of tiles tracked (r = 0.44, 47 df, P = 0.01). Likewise, the average percentage of tiles tracked was weakly related to the stalk damage survey (r = 0.47, 47 df, P = 0.01). The amount of variation in any 1 variable explained by another was not >22%.

Harvest Damage Assessment

Harvest damage measurements and average monthly damage surveys were related (r = 0.79, 11 df, P = 0.001), similar to the correlation between harvest damage measurements and average number of roof rats trapped on the first night (r = 0.85, 11 df, P = 0.001). We found a comparable correlation between average monthly damage surveys and average number of animals trapped on the first night (r = 0.70, 11 df, P = 0.006). We also related each month's damage survey with harvest damage measurements, resulting in correlations ($P \leq 0.011$) of 0.83 for September, 0.73 for October, 0.79 for November, and 0.65 for December. The consistently good correlation of the damage survey results throughout the fall indicates that early damage detection is possible with a survey effort comparable to ours.

In 4 of 5 fields in the current study, a harvest damage level of ≥7% rat-damaged stalks was associated with a December damage level of >100 damaged stalks observed (Table 1). In the fifth field, 46-E-34, damage observed in the monthly surveys was low (0–12 damaged stalks/month) relative to the harvest damage level of 7.8% damaged stalks (Table 1). This result is probably related to unevenness of damage distribution throughout fields and edge-biased sampling in our damage survey. In 46-E-34, almost twice as many stalks examined in field centers (82 of 800, 10.2%) were rodent damaged as in field edges (46 of 850, 5.4%). In another field, 46-O-15, the difference between center and edge damage was also large, 131 of 700 (18.7%) in the center and 95 of 850 (11.2%) in the edge. The efficacy of many short transects that sample only field edges should be contrasted with fewer, longer transects that also sample field centers.

Trap Comparisons

The F-tests for trap comparisons were not sensitive because of the small number of degrees of freedom for testing, and we believe that P-values <0.10 indicate an effect that merits further study. There were no P-values <0.10 for number of trap failures, but for number of roof rats captured, both trap type (F = 11.89; 2,2 df; P = 0.078) and day (F = 64.00; 1,1 df; P = 0.079) met this criterion.

Fewer rats were captured on the second day ($\bar{x}$ = 2.3) than the first day ($\bar{x}$ = 3.2). Tomahawk traps captured the greatest number of rats ($\bar{x}$ = 6.1), followed by Haguruma traps ($\bar{x}$ = 2.1) and Havahart traps ($\bar{x}$ = 0.17).

The finding of Lefebvre et al. (1985) that roof rats in sugarcane exhibit a high degree of learned trap avoidance is supported by the livetrapping results; the second day of trapping produced significantly fewer animals. The poor correlation of monthly trapping results (r = 0.28) with the damage surveys could be related to trap shyness. Greater trapping success might improve correlation of trapping results with damage surveys. The trap comparison study indicated that better trapping success could have been achieved with the Tomahawk traps than the Haguruma or Havahart traps.

Roof rat fecal pellets frequently were found on top of traps, indicating that rats may investigate traps before entering them. Temme and Jackson (1979) noted that, in captive experiments, Norway rats (*R. norvegicus*) approached live traps much more cautiously than snap traps, stopping and sniffing at the door and occasionally moving completely up onto the live trap for a brief period. Such behavior may sometimes set off live traps prematurely. The smaller door of the Haguruma trap and the double door arrangement in the Havahart trap may have contributed to their lower trap success. In a study design where fields are trapped only once, snap traps may provide greater success than live traps.

MANAGEMENT APPLICATIONS

Damage surveys are the most practical means for a sugarcane grower to index rodent populations and to assess potential damage. Damage surveys require no equipment, unlike trapping and tile tracking, and relate well to damage at harvest. We started our damage surveys in September because earlier work indicated that rodent damage to sugarcane in South Florida does not become appreciable until August (Holler et al. 1981). Our study did not indicate that monitoring earlier than September is warranted; however, our small sample of fields did not include any with severe damage.

Conservative guidelines for conducting field damage surveys would be to start monitoring fields in September and continue monthly surveys if $\geq$2 rodent-damaged stalks/field are observed. If $\geq$10 damaged stalks are observed in October and $\geq$20 are observed in November, consider alternatives of harvesting the affected field(s) earlier than scheduled (e.g., Dec instead of Jan or Feb) or applying a rodenticide treatment if an effective registered bait is available.

These guidelines are based upon assumptions that the grower's survey is at least as intensive as ours and that a harvest damage level of $\geq$7% would result in significant profit loss. The latter assumption is based upon the correlation of 1975 rat damage assessment at harvest in 40 fields in the same study area (West. Div., U.S. Sugar Corp.) and amount of cane lost per hectare (Lefebvre et al. 1978). A mean of 14% of stalks examined per field were damaged by rats in that study, resulting in estimated losses of millions of dollars to the grower-processor. It is reasonable to assume that half of this damage level will result in a significant economic loss.

If a grower determines through damage surveys that some fields may sustain significant damage by harvest, snap traps should be placed along field edges to determine which rodent species is (are) present. The other common damaging species in South Florida sugarcane fields is the cotton rat (*Sigmodon hispidus*). Although some fields may have both roof and cotton rats, 1 species generally seems to be predominant (U.S. Fish and Wildl. Serv., Gainesville, Fla., unpubl. data). The efficacy of ZP® Rodent Bait AG (Bell Lab., Madison, Wis.) has been tested on both roof rats (Lefebvre et al. 1985) and cotton rats (Holler et al., unpubl. data) in separate field studies. Although not effective in reducing roof rat populations, ZP Rodent Bait AG did significantly reduce cotton rat numbers in treated fields. Our guidelines for monitoring damage caused by roof rats may not be applicable to fields with cotton rat populations. Research is needed to determine if a similar relationship exists between preharvest survey and harvest assessment results for damage caused by cotton rats.

SUMMARY

Correlations of 3 types of roof rat population indices with rat damage at harvest were determined for 12 South Florida sugarcane fields. The 3 monthly indices (average percentage of tiles tracked, number of rats captured on the first night of livetrapping, and number of damaged stalks observed in preharvest field surveys) were not highly intercorrelated. Percentage of stalks damaged in each field at harvest correlated well with the mean (over months) damage survey (r = 0.79) and livetrapping (r = 0.85) results. Also, damage surveys from individual months correlated well with harvest damage (r = 0.65–0.83). Monthly preharvest damage surveys appear to be the most suitable index method for a sugarcane grower to assess potential rat damage. Future research should investigate the relationship of preharvest surveys and harvest damage levels, with a larger number of study fields and short versus long survey transects.

Acknowledgments.—The study was supported by the Florida Sugar Cane League. We thank J. R. Orsenigo, M. Dyal, and J. W. Beardsley for assistance in coordinating the study, and G. R. Gutknecht, C. D. Hillman, and P. W. Lefebvre for their field assistance. We also thank R. D. Lord and an anonymous referee for their helpful reviews.

LITERATURE CITED

HOLLER, N. R., L. W. LEFEBVRE, AND D. G. DECKER. 1981. Ecology and control of rodent depredations to Florida sugarcane. Proc. Am. Soc. Sugar Cane Technol. 10:183–188.

KAUKEINEN, D. E. 1979. Field methods for census taking of commensal rodents in rodenticide evaluations. Pages 68–83 *in* J. R. Beck, ed. Test methods for vertebrate pest control and management materials. Am. Soc. Test. Mater., ASTM STP 680.

LEFEBVRE, L. W., N. R. HOLLER, AND D. G. DECKER. 1985. Efficacy of aerial application of a 2% zinc phosphide bait on roof rats in sugarcane. Wildl. Soc. Bull. 13:324–327.

———, C. R. INGRAM, AND M. C. YANG. 1978. Assessment of rat damage to Florida sugarcane in 1975. Proc. Am. Soc. Sugar Cane Technol. 7:75–80.

———, D. L. OTIS, AND N. R. HOLLER. 1982. Comparison of open and closed models for cotton rat population estimates. J. Wildl. Manage. 46:156–163.

SAMOL, H. H. 1972. Rat damage to sugarcane in Florida. Proc. Int. Soc. Sugar Cane Technol. 14:575–580.

TEMME, M., AND W. B. JACKSON. 1979. Criteria for trap evaluation. Pages 58–67 *in* J. R. Beck, ed. Test methods for vertebrate pest control and management materials. Am. Soc. Test. Mater., ASTM STP 680.

Received 7 January 1988.
Accepted 25 September 1988.